

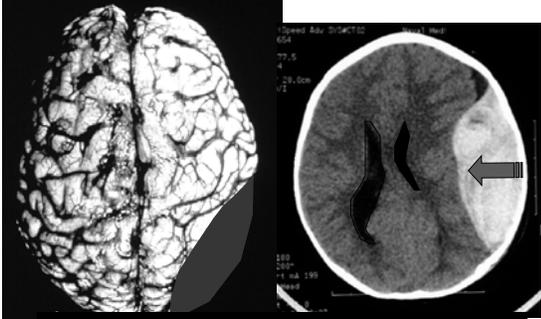
Essentials of Neuroradiology

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 Bethesda, MD
 And
 Armed Forces Institute of Pathology
 Washington, DC

Learning Objectives

- Recognize Urgent Lesions
- Understand Acute Traumatic Lesions
- Describe four types of herniation
- Triage Acute Vascular Lesions
- Recognize Diffuse cerebral swelling

2 y.o. with dilated pupil



Midline Herniation: Subfalcine and Downward Transtentorial

EPIDURAL HEMATOMA

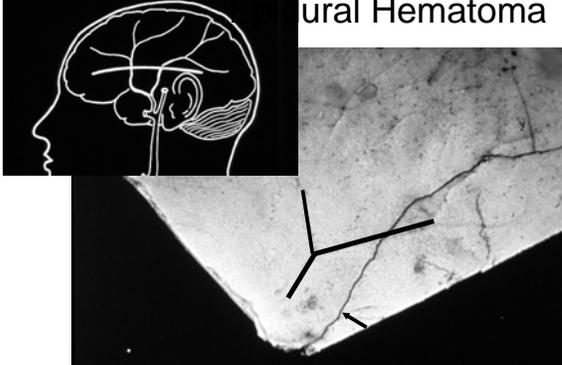
- Significant trauma
- Fracture & concussion (l.o.c.)
- **Lucid Interval**
 - pt Wakes Up
 - 40% pts.
- Delayed neurologic Sx (hrs. Later)
- Herniation, coma and death

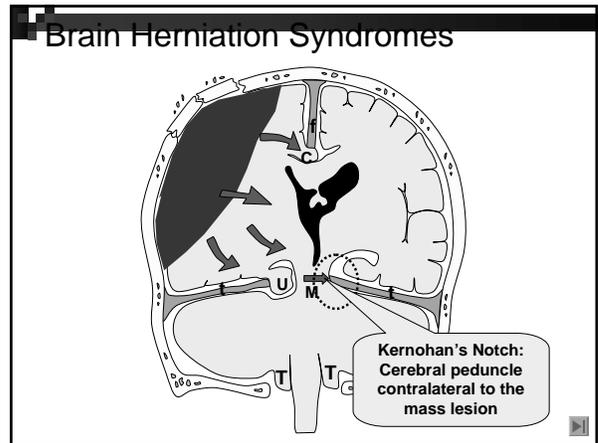
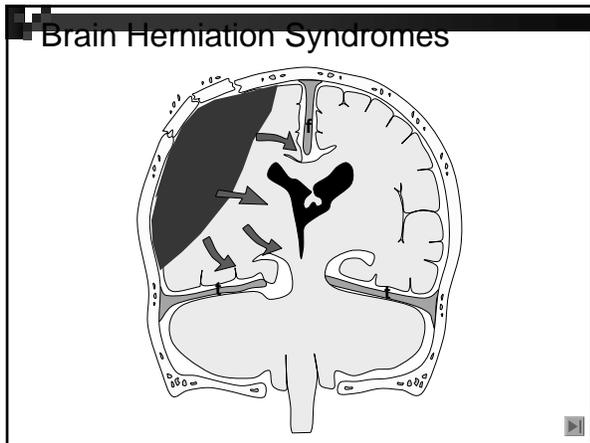
EPIDURAL HEMATOMA



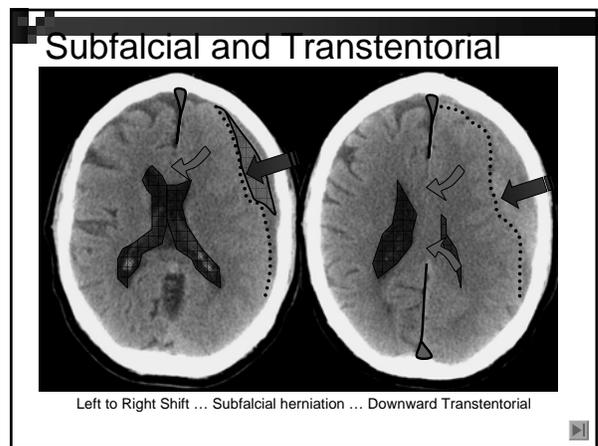
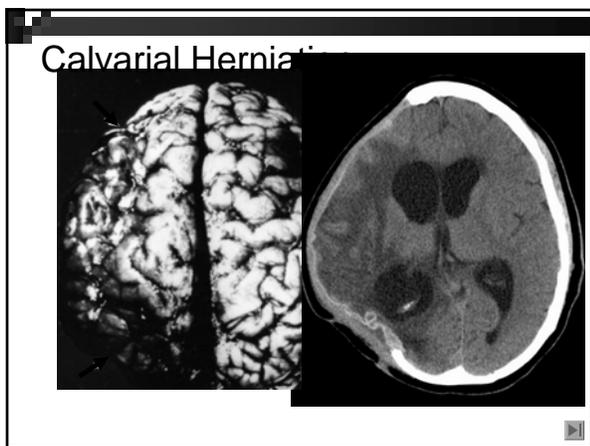
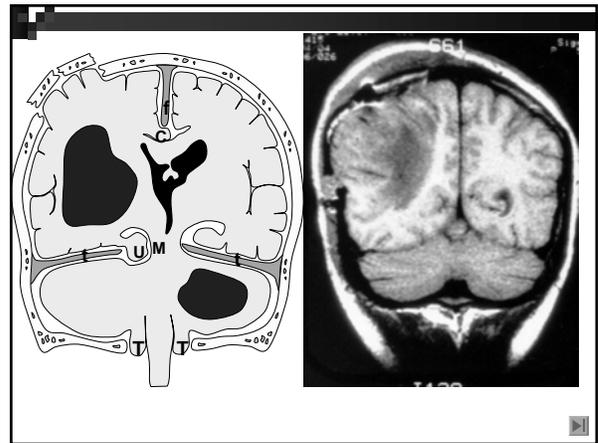
Trauma -> fracture & concussion
 Tearing/stripping of both layers of dura away from inner table
 Laceration of outer periosteal layer of dura
 Laceration of meningeal vessels
 Inner (meningeal dura) intact
 Blood between naked bone and dura
NORMAL arterial pressure continues to dissect

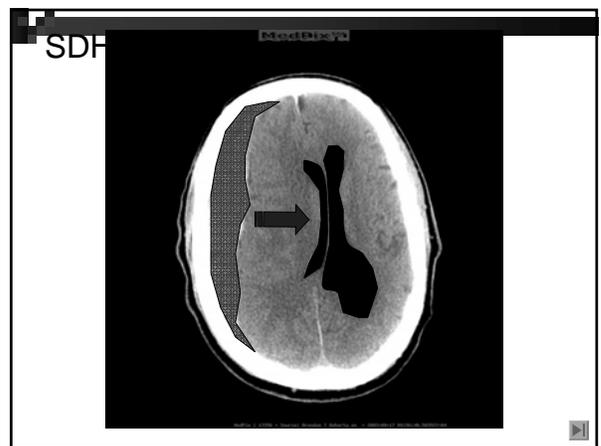
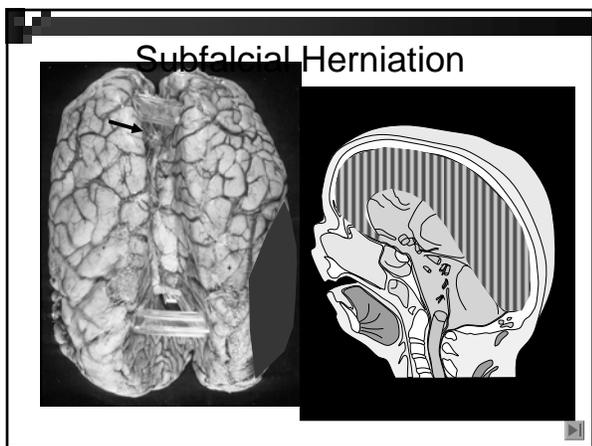
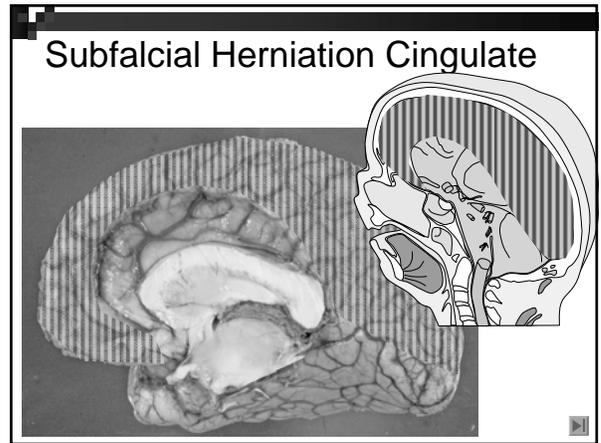
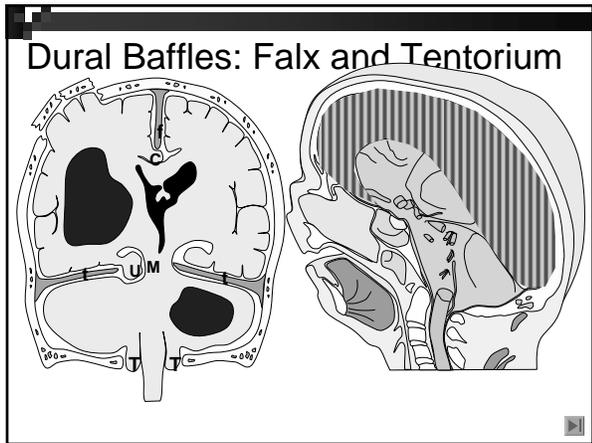
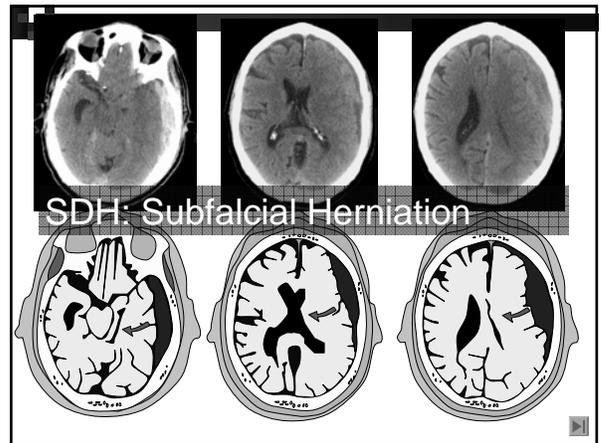
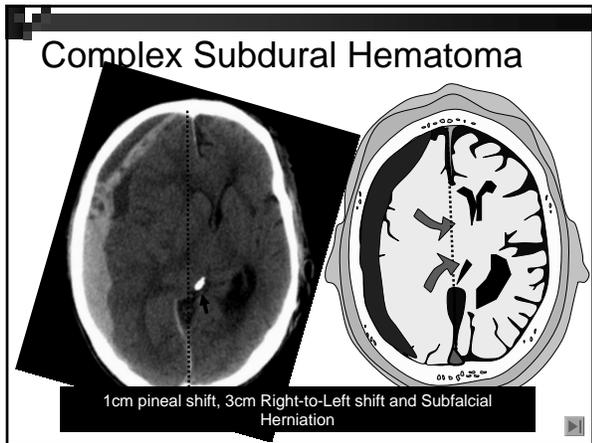
ural Hematoma

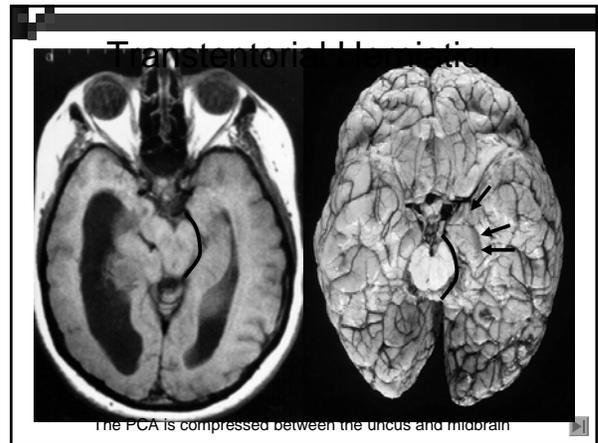
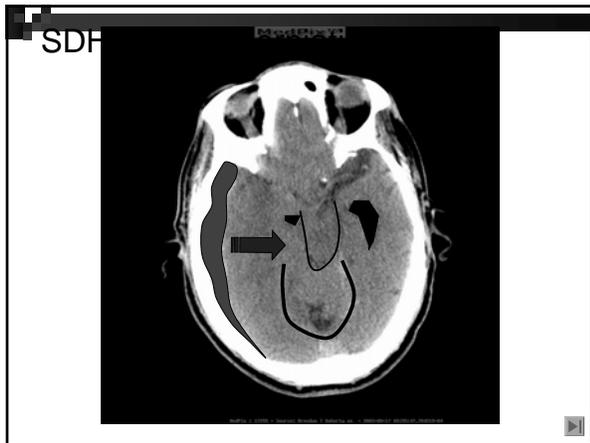




- ### Four Types of Brain Herniation
- Transcalvarial – cerebral cortex
 - Subfalcial – Cingulate Gyrus
 - Transtentorial
 - Downward – Uncus and Temporal Lobe
 - Upward – Vermis
 - Foramen Magnum – Tonsils and Medulla

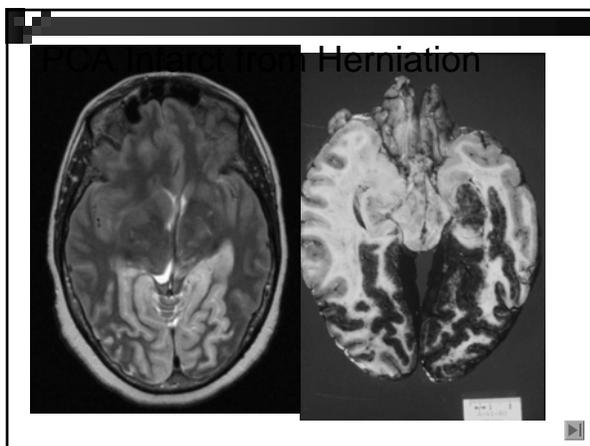
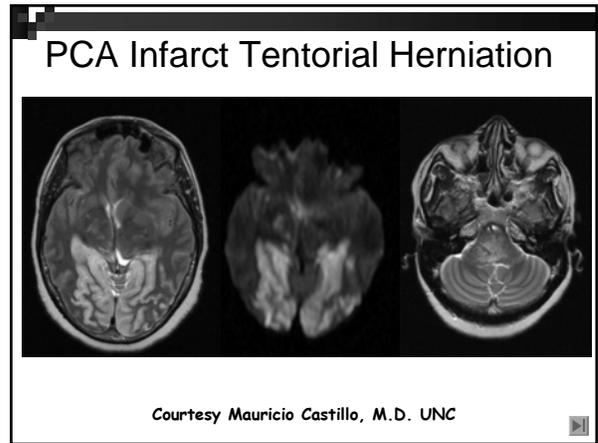






Tentorial hiatus and Midbrain

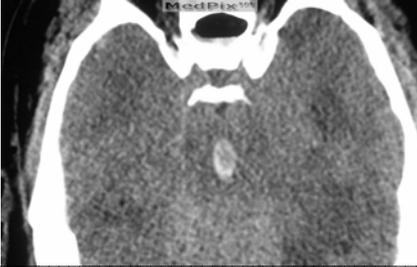
- Superior Cerebellar a.
- Oculomotor nerve (CN3)
- Posterior Cerebral a.
- Temporal Herniation
 - Compresses CN3
 - Compresses PCA



Diffuse cerebral swelling

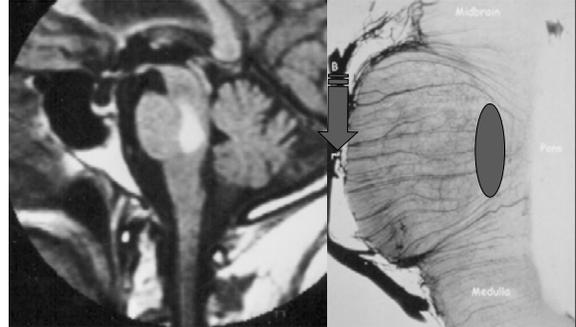
- Anoxic Damage
- Loss of Autoregulation
- "Comotio Cerebri"
- Secondary herniation
 - Duret Hemorrhage

30 y.o. man after motor cycle crash with facial swelling and facial fractures. Acute alteration in level of awareness.

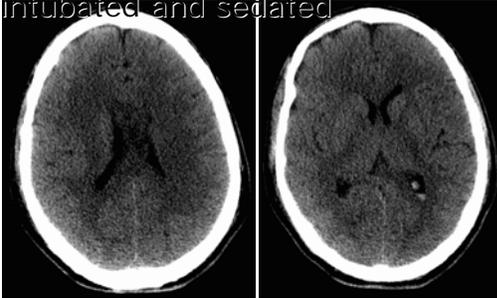


No sulci, no cisterns, low-attenuation both temporal lobes, brainstem (mid-brain) hyperattenuating lesion.

Duret Hemorrhages

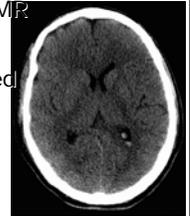


25 y/o man from a helicopter crash. Upon arrival, patient was intubated and sedated.



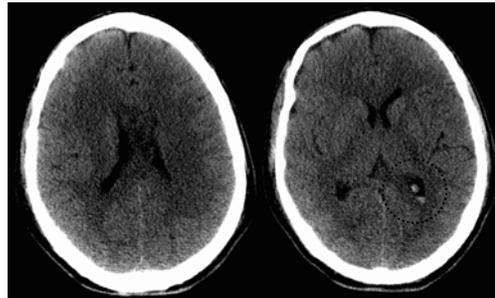
After reviewing this CT, what would you do next ?

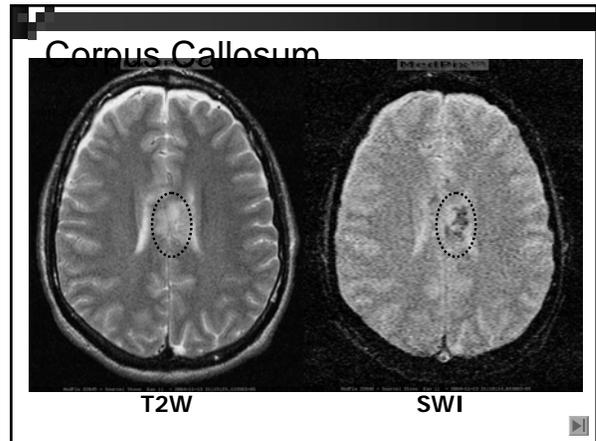
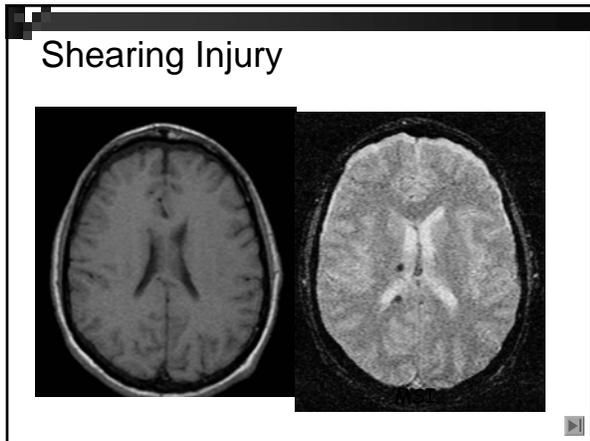
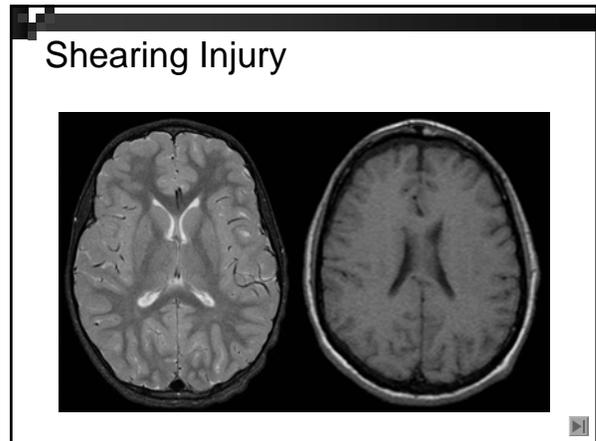
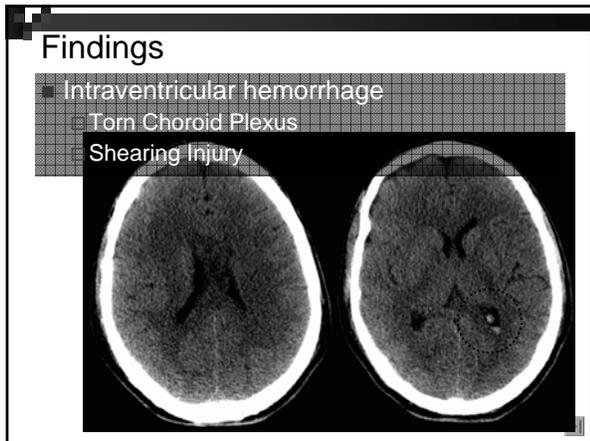
- Suggest FLAIR MR
- Suggest Magnetic Susceptibility Image (MSI or SWI)
- Suggest Diffusion Weighted MR
- Make Diagnosis
- a, b, and c are ALL suggested



3 Reasons for Getting an MR

- CT fails to explain Pt's Condition
- CT fails to explain Pt's Condition
- CT fails to explain Pt's Condition





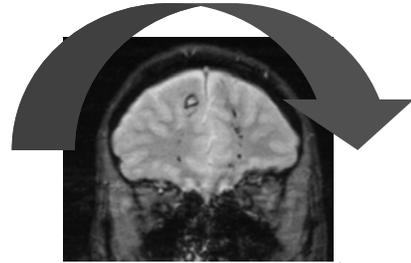
- ### Deep Lesions - Terminology
- Intermediate Contusions
 - Shearing Injury
 - Diffuse White-matter Injury (DWI)
 - **Diffuse Axonal Injury (DAI)**

- ### SHEARING INJURIES
- **Deep lesions**
 - High Velocity (MVA) Trauma
 - Acceleration/Deceleration
 - Especially CORONAL angular momentum
 - Side Impact (Running a Red Light)
 - Do not require an impact or Fx.
 - **“SHEARING OF AXONS”**
 - Breaks connections
 - Actual force may be tension
 - **“SHEARING” of Small WM VESSELS**
 - Small (petechial) hemorrhages

DIFFUSE AXONAL INJURY

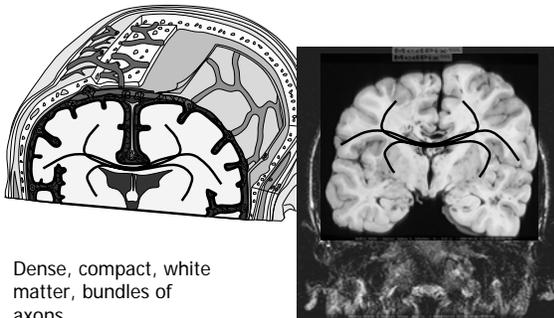
- **Neurologic Sx Begin at Impact**
- Some have Immediate L.O.C.
- Some have Persistent Vegetative State
- Pathology:
 - foci of hemorrhage in corpus callosum, brainstem, etc.
 - axon retraction balls (ARB)
- Long-Term Survivors:
 - microglial clusters
 - foci of demyelination

Deep Lesions – Coronal Forces



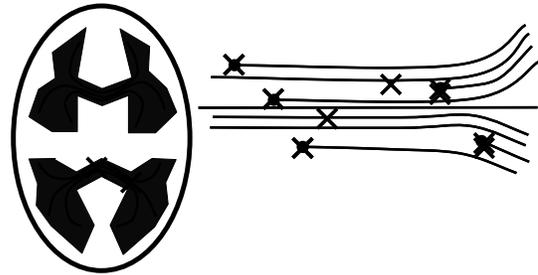
Angular momentum in the Coronal Plane:
Running a Red Light ... T-Bone the cars

Corpus Callosum



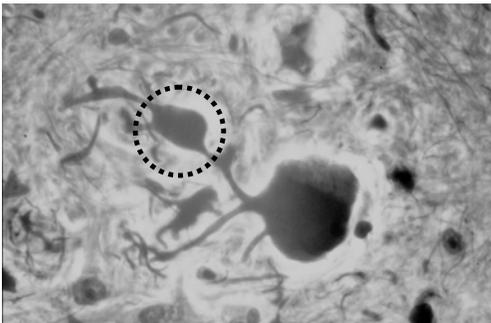
Dense, compact, white matter, bundles of axons

WM – Axonal Transection

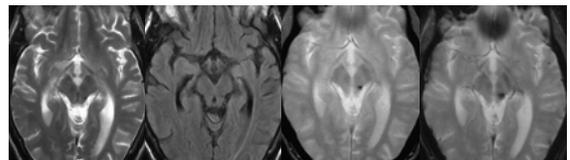


Axon Retraction Balls – Cytoplasm leaking from transected axons and disrupted axolemma.

Axon Retraction Balls



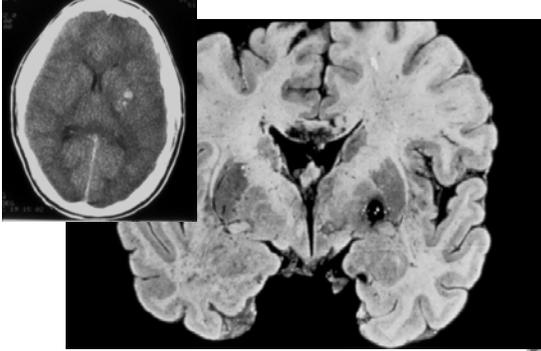
Diffuse axonal injury (Magnetic Susceptibility)



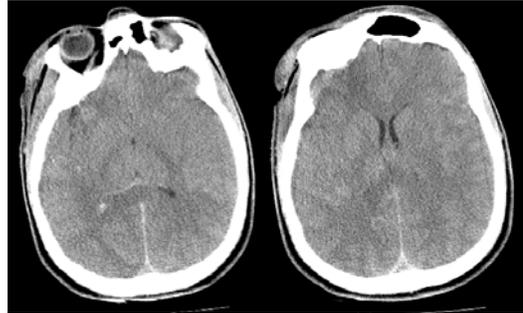
TSE T2 Turbo FLAIR FLASH T2* FLASH T2*
TE: 15 ms TE: 35 ms

Ref. Parizel PM et al. Eur. Radiol. 1998; 8: 960-965

Corpus Callosum and BG

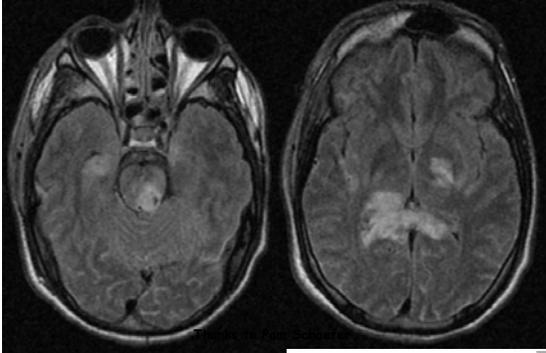


Unconscious Patient - CT

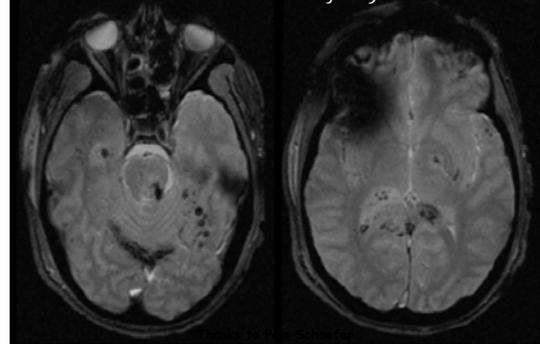


Thanks to Pam Schaefer

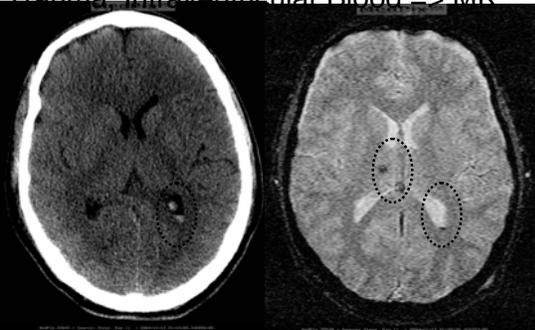
Diffuse Axonal Injury - FLAIR



Diffuse Axonal Injury - MSJ



Trauma, Intraventricular Blood => MR

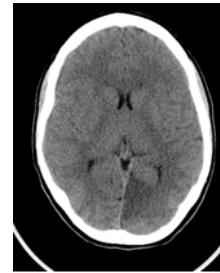


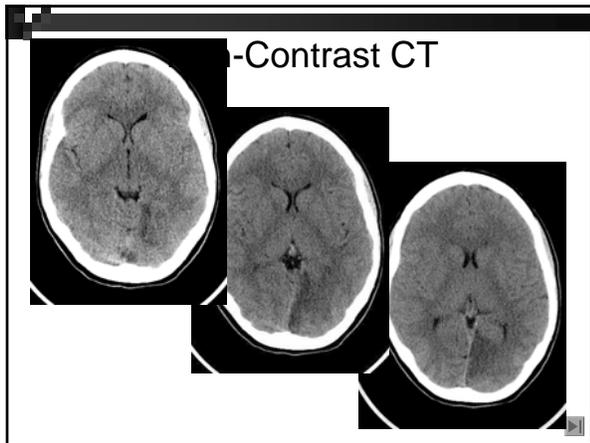
CT

SWI

Blindness

45 y.o. man with acute onset of homonymous hemianopsia

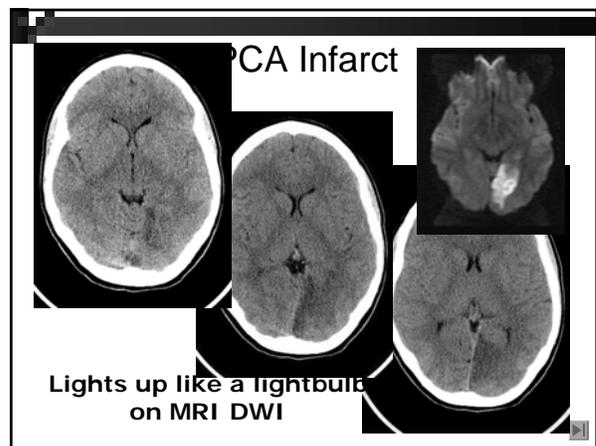
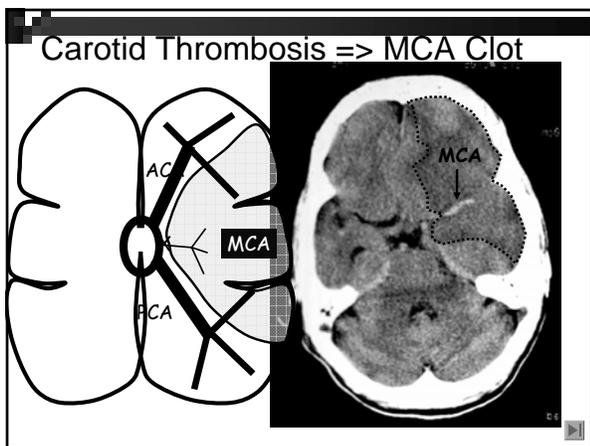
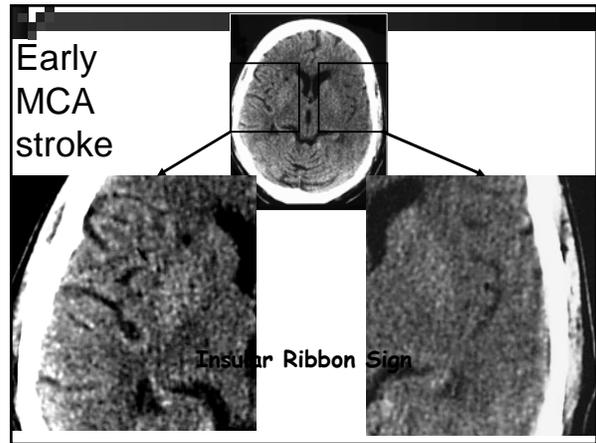


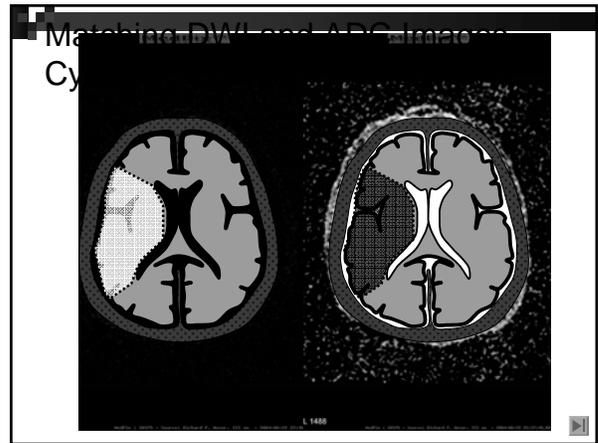
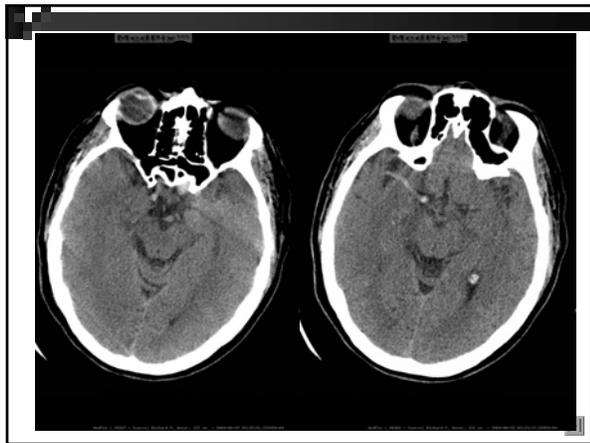
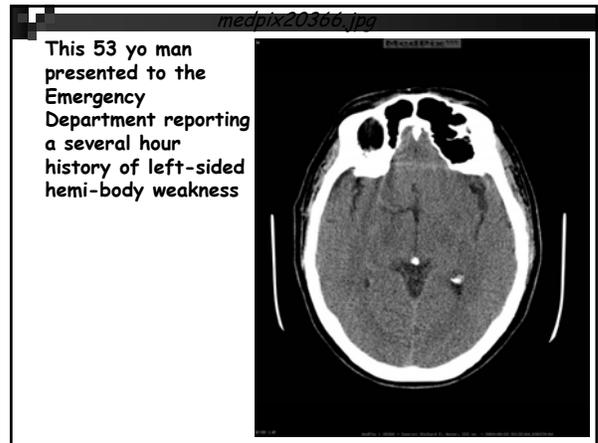
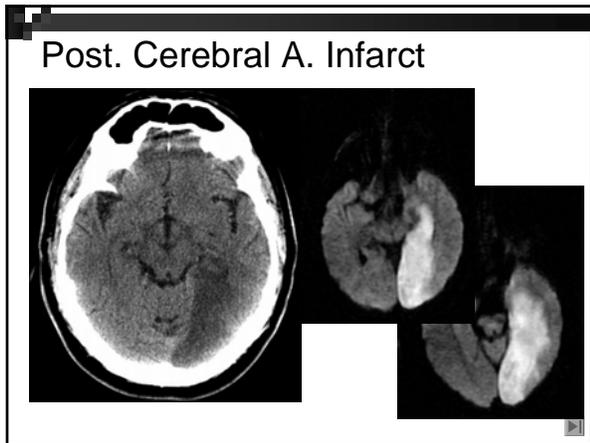


- ### What we see - Findings
- Axial CT
 - Abnormal Cortex and WM
 - Where?
 - Medial Occipital Lobe
 - Minimal mass effect

- ### Imaging Infarction
- CT abnormal in hours
 - MR abnormal in minutes
 - Insular ribbon sign
 - Increased water
 - Hyperdense MCA } **Intraluminal clot**
 - Hyperintense MCA }
 - Vascular (intravascular) enhancement

 - DWI Bright } **Intracellular Cytotoxic Edema**
 - ADC Dark }





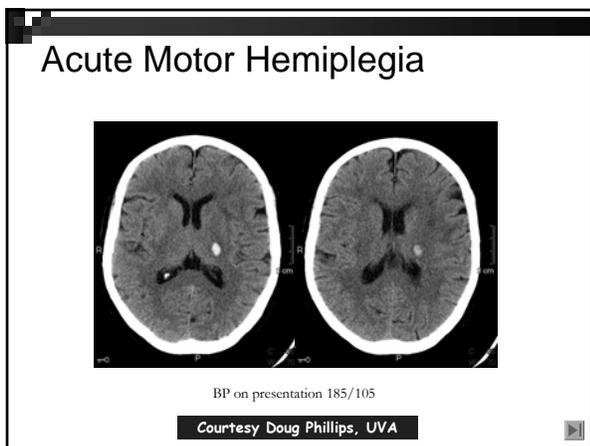
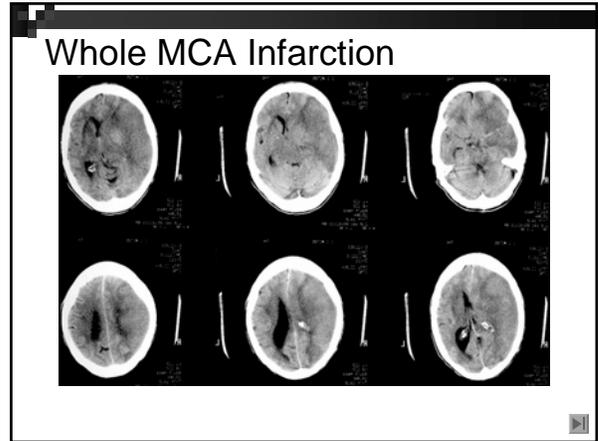
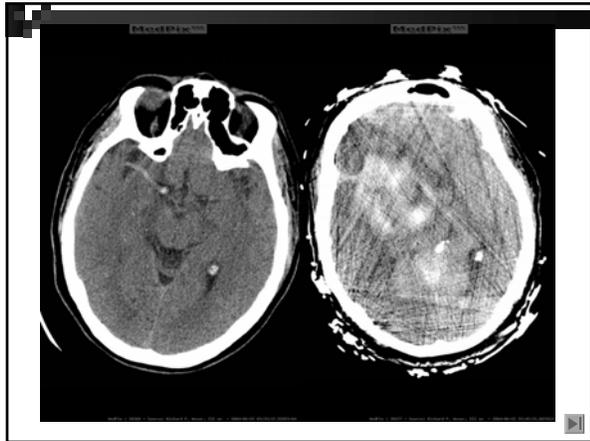
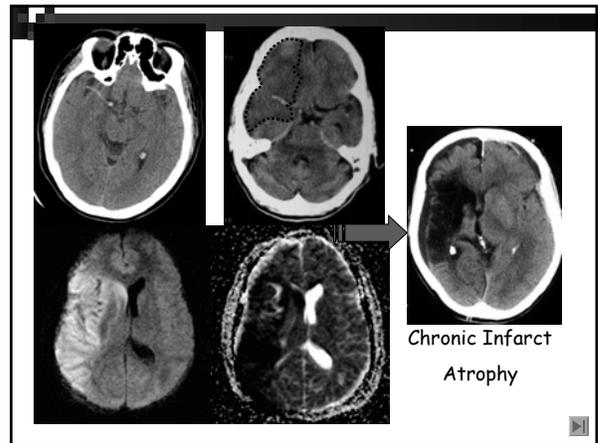
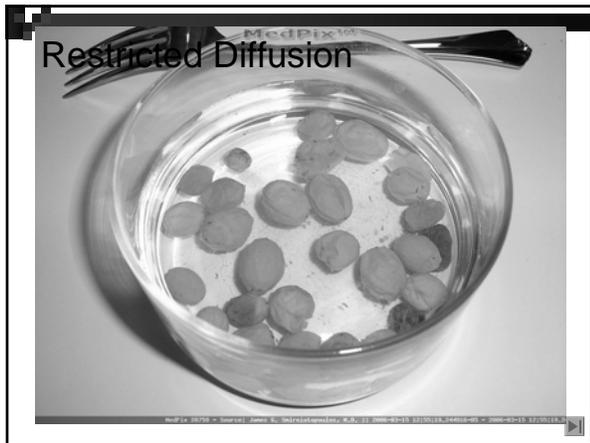
Cytotoxic Edema

- Normal $\text{Na}^+ \leftrightarrow \text{K}^+$ pump
 - K goes In
 - Na goes Out
- Energy Dependent
 - Glucose
 - O_2
 - ATP

Normal Neuron

Swollen Dead Neuron





- ### INTRA-CEREBRAL HEMORRHAGE
- Dense and Homogeneous
 - Round/oval shape
 - Basal ganglia/deep white
 - Proportional mass effect
 - Extension into ventricle



Hypertensive Hemorrhage

BP on presentation 210/110

Courtesy Doug Phillips, UVA

Hypertensive Hemorrhage

- Basal Ganglia
- Internal/External Capsule
- Thalamus
- Dentate Nucleus
- Pons
- Lobar

Courtesy Doug Phillips, UVA

“Found Down”

68 year old man with confusion and acute hemiplegia.

NOTE: Vasogenic Edema

Courtesy Doug Phillips, UVA

Glioblastoma multiforme, WHO 4

Courtesy Doug Phillips, UVA

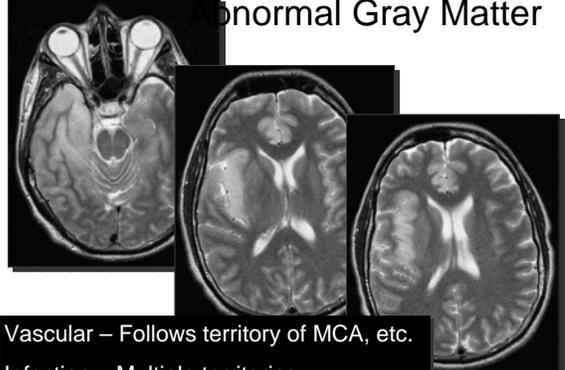
“Found Down”

34 yo marine stationed at Guantanamo Bay Cuba, presenting w/ acute mental status changes, febrile.

Abnormal Gray Matter

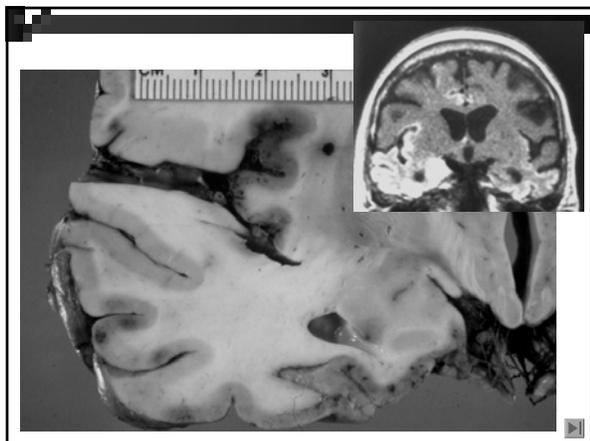
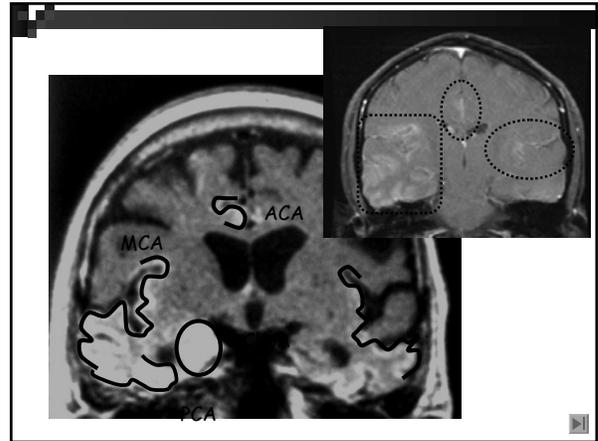
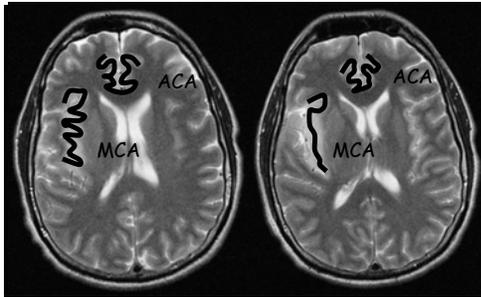
- Vascular
 - Ischemia
 - Infarction
 - Hyperemia (Migraine, Seizures)
- Inflammatory
 - Encephalitis
 - Meningo-Encephalitis
 - Vasculitis

Abnormal Gray Matter

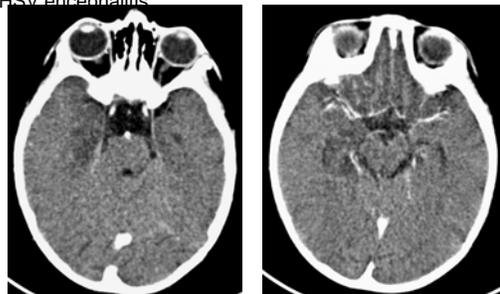


Vascular – Follows territory of MCA, etc.
 Infection – Multiple territories

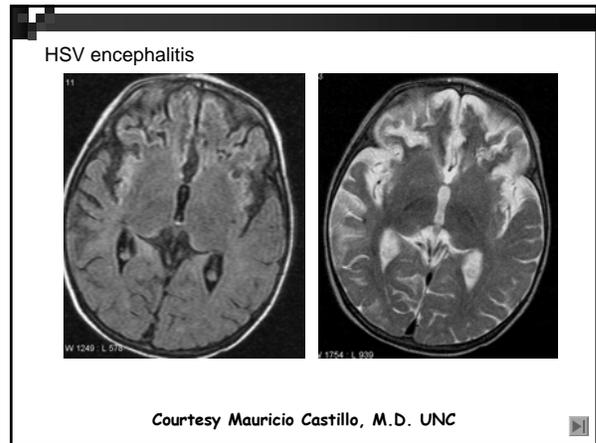
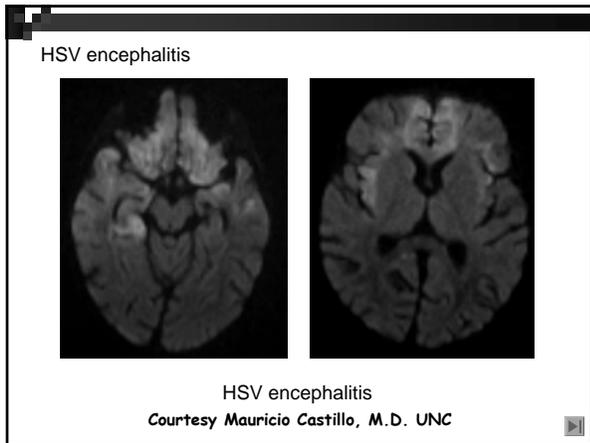
Non-Vascular » HSV Encephalitis



HSV encephalitis



Courtesy Mauricio Castillo, M.D. UNC



What do they have in Common?

- Multiple
- Bilateral
- Symmetric
- Anatomic
- Basal ganglia

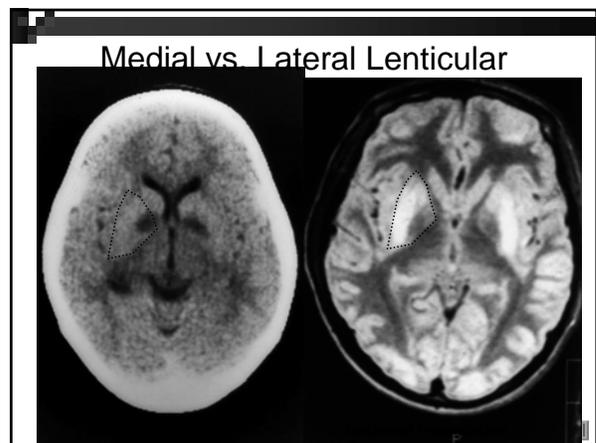
Toxic and/or Metabolic:

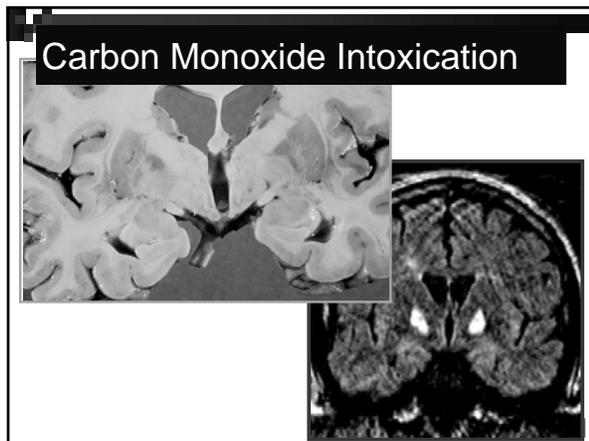
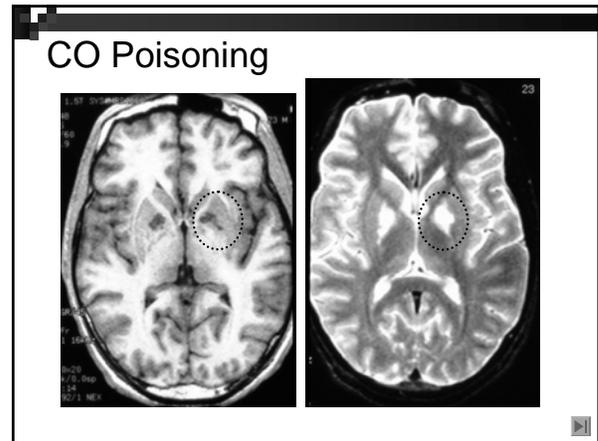
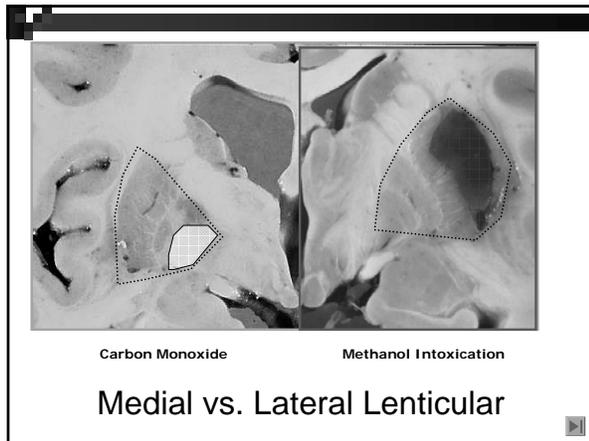
- Acquired
- Congenital

Toxic/Metabolic

Metabolic

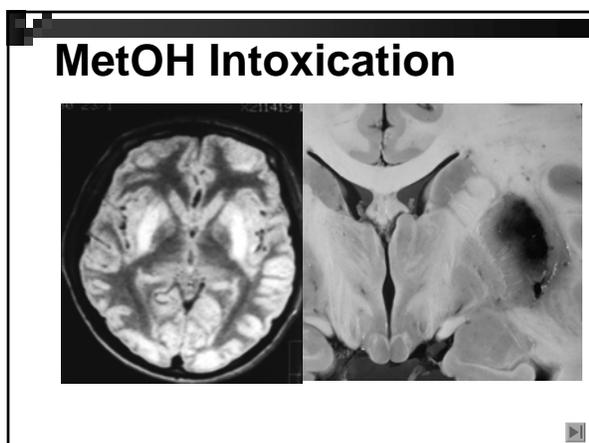
- Intrinsic
 - Diabetic Ketoacidosis
 - Hypoglycemic Coma
- Extrinsic
 - Toxic Exposures
 - CO and Methanol





CO Intoxication

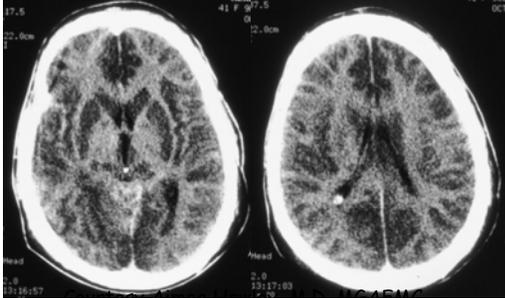
- CO binds to Hgb 240X stronger than O₂ making **carboxyhemoglobin**
- Sx: HA, Lethargy, weakness, dizziness, nausea, confusion, and SOB
- TX is to displace CO with O₂
 - T_{1/2} for CO is 320 min on room air
 - 80 min on 100% O₂
 - 23 min at 3 atm 100% O₂



Tx for MetOH - Fomepazole

- ❖ Fomepazole (Antizole, 4-methylperazole) is a synthetic alcohol dehydrogenase inhibitor for IV administration
- ❖ Clear yellow liquid, mw 82.1, mp 25° C (77° F)
- ❖ INDICATIONS: Antidote for ethylene glycol, or methanol poisoning or suspected EG ingestion
- ❖ PRECAUTIONS: Dilute in > 100 mL NS, follow hepatic enzymes & WBC (eos) during Rx, interaction with ethanol (compete for ADH)
- ❖ DOSE: 15 mg/kg load, 10 mg/kg Q 12 h x 4 doses, then 15 mg/kg Q 12 h till EG < 20 mg/dL

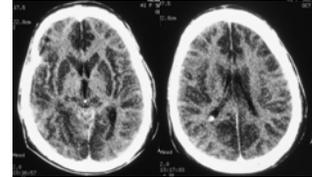
34 yo comatose woman,
psychiatric pt.



Courtesy Aimee Hawley, M.D. MOA/PMC

Findings

- Intraaxial
- **Diffuse Bilateral abnormalities**
 - Low attenuation in Cortical Gray Matter
 - Low attenuation in Basal Ganglia
- “Edema”
 - What Kind?
 - Interstitial
 - Cytotoxic
 - Hydrostatic



Diagnosis: Cytotoxic Edema

- Cytotoxic Edema
 - Cerebral ischemia
 - Metabolic Poisons
 - CN
 - Triethyl Tin
 - Hexachlorophene
 - Hypoglycemia
- Gray matter > White matter

Lab: Serum Na+ 121

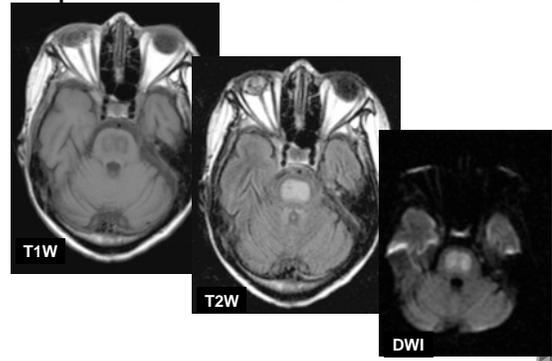
- Psychogenic polydipsia
- Overhydration
 - Athletes drinking too much water
- Iatrogenic
 - D5W w/o salts
- Treatment
 - Hypertonic Saline
 - 2% saline (not 4%)

Causes of Hyponatremia

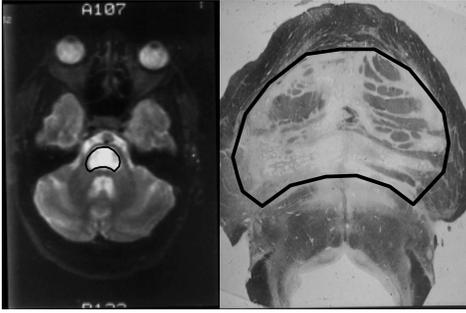
- Increased total body water
 - Excessive water intake
 - Iatrogenic (IV therapy)
- Reduced Urine Output
 - Exercise
 - Heat Exposure
 - Inappropriate ADH
- Sodium Loss
- Inadequate Sodium Intake

Treatment:
Correction by
administration
of IV Saline, or
twice normal,
or ...

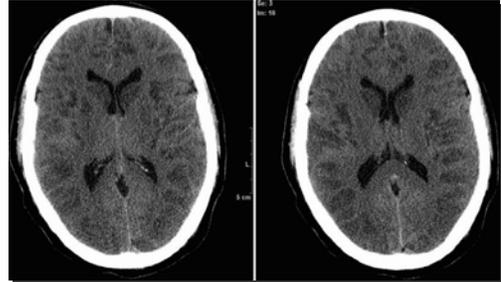
Rapid Correction of serum Na+



Osmotic Myelinolysis

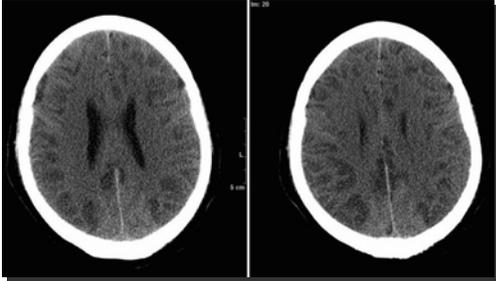


Anoxia During Surgery



Diffuse and Bilateral Gray-matter hypointensities

Anoxia During Surgery



Diffuse and Bilateral Gray-matter hypointensities

Headache

39 y.o. woman with abrupt onset of the "worst headache of my life"

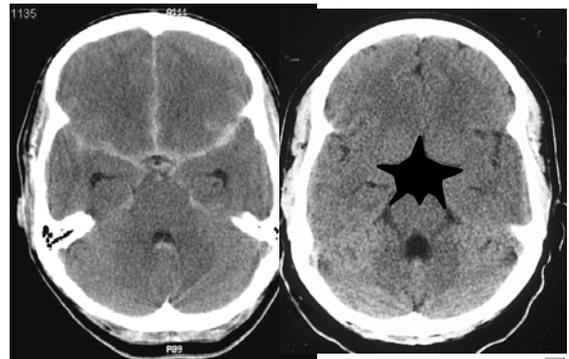


What we see - Findings

- Axial CT
- Abnormal
- Where?
 - Subarachnoid space
- How?
 - Hyperdense



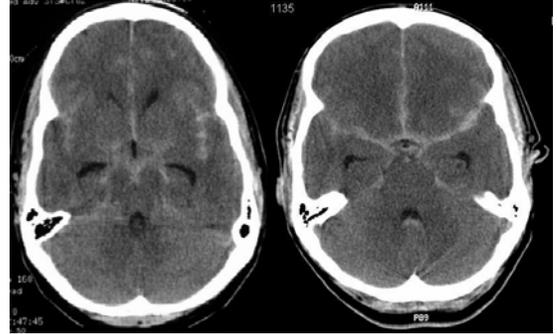
Worst HA: Non-Contrast CT



Aneurysm and Rupture

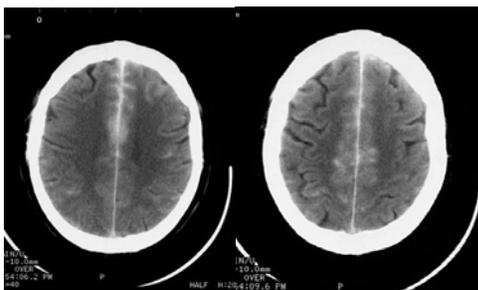
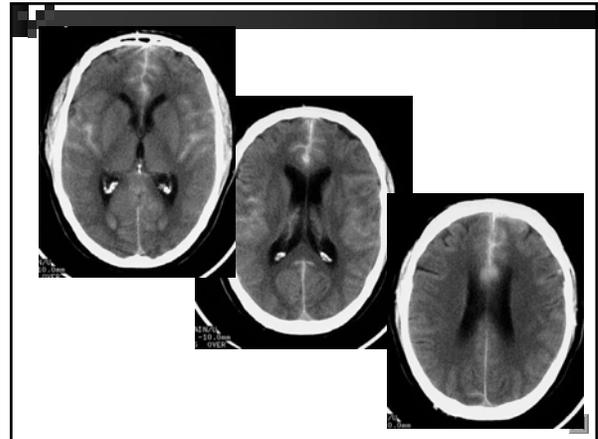
- Clinical Hx:
 - "Worst Headache of My Life"
 - Nuchal Rigidity
 - Photophobia
- Signs: Kernig's, Brudzinski's
- Demographics:
 - Common Cause of Stroke in Young (< 40)
 - Most pts. 40-60yrs
- Risk Factors: Hypertension, ADPKD, CTD (connective tissue)

Subarachnoid Hemorrhage

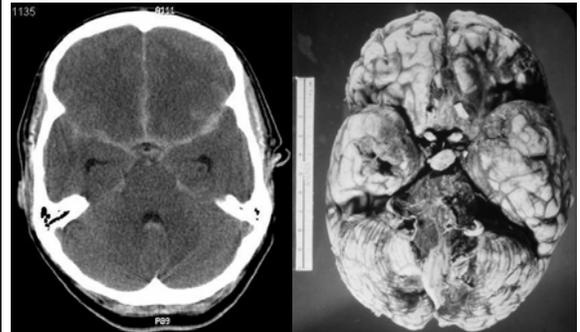


Subarachnoid Hemorrhage

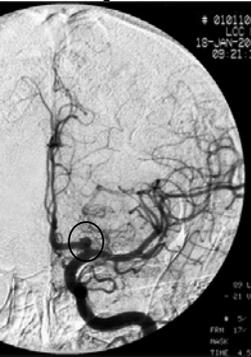
- LP more sensitive than CT
- Trauma is most common cause for RBC'S in CSF
 - Not seen as easily or as often on CT
- SAH on CT
 - Blood clot
 - usually Aneurysm / AVM
 - Uncommon from neoplasm
 - Uncommon from spinal disease



Subarachnoid Clots

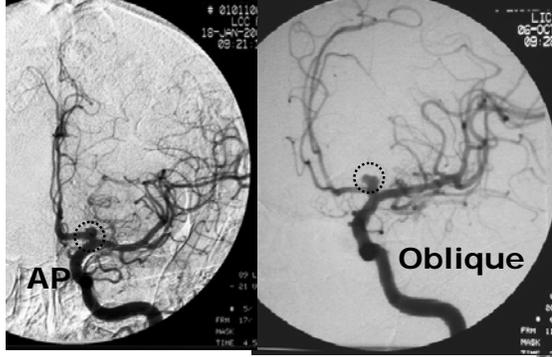


Aneurysm



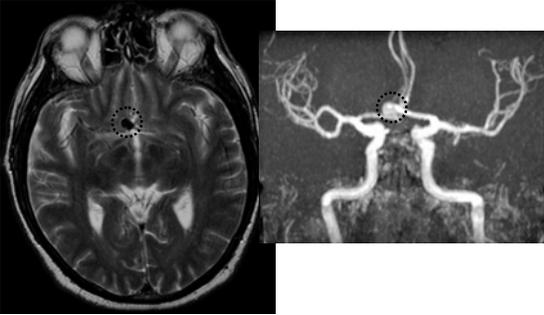
- Round ('berry') shape
- Vessel bifurcation
 - natural weakness
 - exploited by high BP
- Common sites:
 - ACA <-> ACOMM
 - MCA branches
 - Basilar Tip

Angiography - Angiogram



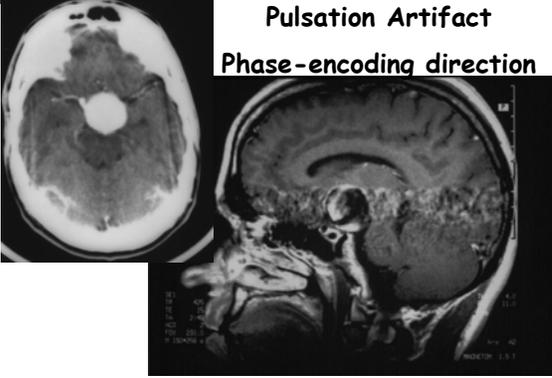
AP Oblique

ICA Aneurysm

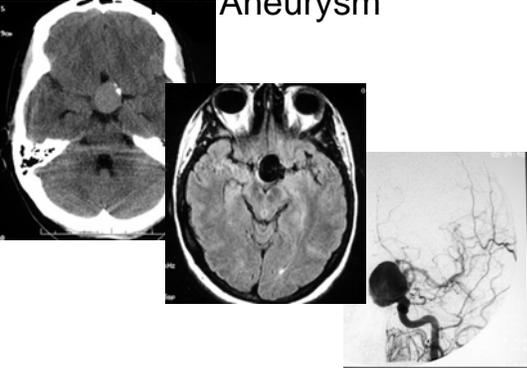


Pulsation Artifact

Phase-encoding direction

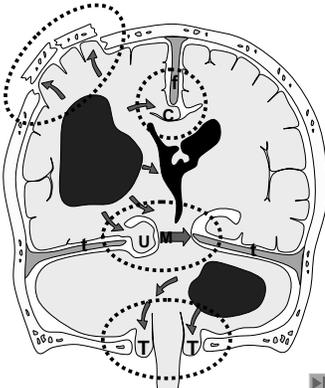


ICA Aneurysm



Summary

- Brain Herniation
 - Epidural
 - Subdural
- Trauma
 - Ventricular blood
 - Shearing Injury
- Gray matter
 - Encephalitis
 - Ischemia/Infarction
- Toxic/Metabolic
 - Co vs. Methanol



Go Raimh Maith Agat

Thank You!

Muito Obrigado

EUXΑΡΙΣΤΩ !

Mahalo !

Dank u wel !

Merci Beaucoup

Danke Schön !
Mil Gracias

